



Alcohol availability around schools and adolescent consumption: A case study in Madrid, Spain

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ABSTRACT

Evidence on the relationship between alcohol environment and adolescents' alcohol consumption remains inconsistent. This cross-sectional study explored the association between alcohol availability around schools and adolescent alcohol consumption in Madrid, a European city with high availability. We quantified alcohol availability as the number of alcohol outlets within 500m street network buffers around 49 schools located in areas with different Socioeconomic Position (SEP). Questionnaires were distributed to students aged 14-18 attending these schools, including sociodemographic and alcohol consumption measures (ever drunk, past 30 and 7 days and binge drinking in the past 30 days). Data were collected during 2021-2022. We designed a Directed Acyclic Graph to identify the minimal adjustment set for Robust Poisson regression models assessing the association between alcohol availability and consumption. The mean number of alcohol outlets around schools was 79. 67% of students reported ever drinking, with higher prevalences among females, older students, and those receiving more pocket money, with low-risk perception, or reporting higher parental alcohol consumption. Students from high SEP areas reported more drinking than those from low SEP areas. Consumption was not associated with alcohol availability around schools. This aligns with emerging evidence suggesting that in highly saturated urban environments, the relationship between outlet density and consumption may follow a threshold-effect, where additional outlets no longer increase use. Adolescent consumption was high overall, and the observed overprovision of outlets may contribute to the normalization of drinking. Future research should inform preventive strategies and public health policies that tackle the complex dynamics of alcohol consumption.

1. Introduction

Alcohol has been identified as one of the major contributors to the burden of disease globally (Rehm et al., 2021). Consumption usually starts during adolescence, and has been associated with a range of problems in this population group, including impaired brain development, violence, unwanted pregnancies, academic failure, and the risk of

illness and cardiovascular disease in later adulthood (Rehm et al., 2017; Lau et al., 2023; Martínez-Manrique et al., 2022; Fan et al., 2017; de et al., 2021; Morris et al., 2019; Manthey et al., 2021; Crosnoe, 2006; Caamaño-Isorna et al., 2018). Despite this, 44% of adolescents aged 15-19 years in the European Union report having consumed alcohol, and this prevalence reaches 73.9% among adolescents aged 14-18 years in Spain (Observatorio Español de las Drogas y las Adicciones, 2025; World

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Health Organization, 2018). Understanding the factors that influence young people to start drinking is crucial for developing and implementing effective preventive policies to improve public health (Villalbí et al., 2014).

Previous research has identified a wide range of individual and contextual factors associated with adolescent drinking behaviors (Elam et al., 2020; Meisel and Colder, 2020; Curtis et al., 2018; Collins, 2016; Teixidó-Compañó et al., 2018, 2022; Wahlström et al., 2023), highlighting the complex interaction between adolescents and their social and physical environments. Within these contextual factors, some studies have focused on the physical availability of alcohol outlets, defined as the number or density of retail points selling alcohol within a given area (Cardoza et al., 2020; Martins et al., 2019; Jackson et al., 2016; Villalbí et al., 2019). A greater outlet availability might facilitate access to alcohol and contribute to normalization of drinking (Morrison et al., 2019a; Chaix, 2009; Pastor et al., 2020a). As outlet density increases, competition between vendors may intensify, potentially encouraging some to engage in illegal underage sales to avoid losing customers to competitors (Gruenewald, 2007). Such competitive dynamics can also drive down local alcohol prices, making products even more accessible to the population and particularly to adolescents, who usually have less money to spare (Pastor et al., 2020a). Alcohol outlets also function as promotional and advertising showcases for alcohol products, which have been shown to influence consumption in adolescents (Pastor et al., 2020a, 2020b; Osuafor et al., 2023).

Although there is an increase in the number of studies examining the association between alcohol outlet density and alcohol consumption since last years, evidence shows that findings remain inconsistent. A recent systematic review reported that only 53.3% of associations demonstrated a positive relationship between alcohol availability and drinking prevalence in adolescents, and 60.5% with risky drinking patterns, highlighting substantial variability across analyses and methodological approaches (Martín-Turrero et al., 2024). This heterogeneity in results has been partly attributed to limited and uneven adjustment for individual- and areal-level covariates, the types of alcohol outlets analyzed, the methodology used to calculate alcohol outlet density (AOD), and the geographic unit of analysis chosen.

These gaps underscore the need for establishing a formal causal framework prior to model specification, ensuring that all contextual and individual characteristics that shape adolescent drinking behaviors are appropriately considered. Previous studies have incorporated the use of Directed Acyclic Graphs (DAGs), which represent a good practice for formalizing causal assumptions and identifying a minimal sufficient adjustment set when examining the association between alcohol availability around schools and adolescent alcohol consumption. This approach strengthens the theoretical foundation of analyses and enhances transparency and reproducibility (Gullón et al., 2017). Additionally, careful selection of the methodology to calculate AOD and the geographic area of exposure considering the characteristics of the study area is needed, given that these choices may substantially influence results (Martín-Turrero et al., 2023).

Some studies specifically examined the exposure to alcohol around school environments, although these were fewer compared with those that assessed alcohol availability around adolescents' residences or other activity spaces (Martín-Turrero et al., 2024). Heterogeneity of results was found in these studies as well, where some reported a positive association between the alcohol environment around schools and adolescent drinking (Martins et al., 2019; Rowland et al., 2014; Trapp et al., 2018; Wang et al., 2013), and others found no association (Cardoza et al., 2020; Shamblen et al., 2011; Larsen et al., 2017). School environments are spaces where adolescents commute and spend a substantial portion of their daily time, thus exploring how the urban environment in these spaces specifically affect adolescents' health behaviors is of public health interest.

Areas with high alcohol outlet density may represent a special case, as they are often the focus of strategies aimed at reducing outlet

availability to protect the population, particularly adolescents, from alcohol-related harms. The effects of such saturation, including the possibility of a threshold beyond which adding new outlets no longer influences consumption, has been noted by some authors, but it still remains unclear and warrants further investigation. (Sureda et al., 2017; Martín-Turrero et al., 2022).

To address the limited evidence on how alcohol availability around schools relates to adolescent drinking, particularly in urban areas with high alcohol outlet density, this study aims to assess the association between physical availability of alcohol outlets around schools and alcohol consumption among adolescents in Madrid, a well-known alcohol outlet-hyperdense European city (Martín-Turrero et al., 2022). We designed a DAG to draw the minimal adjustment set of variables to explore this association based on existing evidence.

2. Methods

We designed a cross-sectional study with students between 14 and 18 years in the city of Madrid. We recruited a sample of schools from areas with different SEP and conducted surveys among students to explore their alcohol consumption and access to alcohol around schools. We also collected the physical availability of alcohol around each recruited school using Systematic Social Observation (SSO) and calculated alcohol outlet density measures around schools using Geographic Information Systems (GIS). Details on the selection and recruitment of schools are summarized below, but further information can be found in the study protocol (Berasaluze et al., 2023).

2.1. Student sample

We recruited a sample of 2333 students between 14 and 18 years (mean age of 15.7) from 49 secondary schools in the city of Madrid, in the academic year 2021-2022. In Spain, the legal drinking age is 18 years. We decided to include 18-year-olds in our sample to facilitate comparison with other national data (Observatorio Español de las Drogas y las Adicciones, 2025).

Participant schools were reached following a stratified strategy to cover institutions located in areas with varying SEP and density of alcohol outlets. All schools within the city were classified into a total of nine strata by combining three levels of SEP (high, medium, low, see section 2.3.2. for more details) and three levels of outlet density (high, medium, low). A strata-balanced approach was applied to recruit schools, ensuring geographic variability and minimizing location bias by including schools from different strata. Further details on school selection are specified in the study protocol (Berasaluze et al., 2023).

Each secondary school chose the specific courses and classrooms they wanted to enroll in the survey. In Spain, secondary schools are compulsory until the age of 16 (Obligatory Secondary Education). After that age, 16–18-year-old students can choose to continue studying for 2 more years (i.e., Bachillerato or Non-Obligatory Secondary Education) before enrolling in university. Each student completed a self-administered questionnaire after signing an informed consent. The questionnaire included questions to obtain sociodemographic data, patterns of alcohol consumption, and determinants of this consumption (Berasaluze et al., 2023). The Experimentation and Animal Research Ethics Committee of the University of Alcalá (UAH) approved this study (CEI/HU/2020/48), which respects the ethical principles promulgated by the Declaration of Helsinki.

2.2. Individual measures

2.2.1. Individual drinking behaviors

We asked the following questions to evaluate the prevalence of alcohol consumption in life, in the past 30 days, and in the past 7 days: (1) *Have you ever had any alcoholic drinks in your life?* (Yes, No, NR/DK); (2) *Have you drunk in the past 30 days?* (Yes, No, NR/DK); and (3) *Have you*

drunk in the past 7 days? (Yes, No, NR/DK). The response rates were 98.43%, 83.31%, and 97.34%, respectively. Also, to evaluate patterns of consumption (i.e., binge drinking), we asked the following: *(4) In the past 30 days, have you drunk 5 or more glasses of alcoholic drinks during a single occasion?* (Yes, No, NR/DK). The response rate was 91.15%. Answers recorded as NR/DK (Doesn't Respond/Doesn't Know), were counted as Not Applicable (NA) for the analyses. We excluded from the analyses those participants that showed inconsistent responses to the questions about consumption of alcohol (e.g., those students that responded that they had drunk in the past 7 days, but not in the past 30 days) or that had not responded to any of these questions. A total of 2295 adolescents (98.37%) were included in the final analysis (see [Supplementary Material Fig. S1](#) for more details on the number of inconsistencies and participants excluded).

Moreover, to evaluate the perceived easiness of access to alcohol near school, we asked the following question: *How difficult do you think it would be to obtain alcohol near your educational center?* (Difficult or impossible, Easy or very easy).

2.2.2. Sociodemographic individual-level variables

Students reported their age, gender, nationality, pocket money per week, risk perception of alcohol consumption, as well as their parents' educational level and alcohol consumption level in the past 30 days. Age and pocket money were continuous variables. Gender was categorized into Male, Female or Other, nationality was dichotomized into Spanish or Other, and perception of the problems that drinking can cause (hereafter called "risk perception of alcohol consumption") had two categories: a few or no problems and some or many problems. The educational level of parents had two categories: no university education and university education. Parental alcohol consumption in the past 30 days had 5 categories: did not drink, drank a few days, drank on the weekends, drank moderately every day, abuse alcohol every day. This variable reflects adolescents' perceived parental drinking behavior rather than an objective report, capturing their understanding of how often their parents drink. Although perceived consumption may not perfectly reflect parents' actual drinking patterns, perception itself constitutes a meaningful mechanism influencing adolescent behavior. For the analyses, we considered the highest level of education and highest level of consumption reported for either parent.

2.3. School area variables

2.3.1. Physical alcohol availability

We conducted a SSO fieldwork between June and October 2021 around the 49 recruited schools to characterize the alcohol environment. We used GIS to estimate the observation area, defined as 500m street network buffers around each school, corresponding to an approximate 5-min walk to capture the immediate, walkable environment for adolescents ([Zuniga-et al., 2017](#)). We obtained the street network shapefile from OpenStreetMap and used QGIS for all processing steps, including cleaning, topological correction, and buffer calculation. We also created maps showing the boundaries of each observation area to support fieldwork orientation.

The fieldworkers navigated all the streets and public outdoor areas within each observation area and recorded all alcohol outlets. Data collection was facilitated with a validated digitized questionnaire delivered via a purpose-built smartphone application specifically developed for this study ([Berasaluce et al., 2023](#)).

We estimated physical alcohol availability through the measurement of alcohol outlet density, which was defined as the number of alcohol outlets within the 500m buffer around each school ([Zuniga-et al., 2017](#)). Specifically, two types of outlets were registered: on-premises and off-premises alcohol outlets. On-premises alcohol outlets were defined as those places where alcohol products could be purchased and consumed inside the venue, and included restaurants, bars, clubs, taverns, show-bars and wine cellars. Off-premises alcohol outlets were

defined as those where alcohol products could be purchased for consumption elsewhere, and included supermarkets, small grocery stores, minimarkets, convenience stores and liquor stores. Schools were classified in quintiles according to alcohol outlet density around them: low (0-5), middle-low (6-26), middle (27-57), middle-high (58-96), and high (97-491).

The main measure of alcohol outlet density was the total number of both on- and off-premises outlets inside each buffer, to capture the full alcohol-related environment around schools. Moreover, we also calculated separately the density of off-premises outlets and density of convenience stores (a type of off-premises outlet) around schools, since these are the outlets where underage adolescents have the easiest access to alcohol according to data reported in qualitative semi-structured interviews ([Yoon et al., 2017](#)). Separate analyses were done accounting for these specific types of outlets.

2.3.2. Area Socioeconomic Position

Area SEP in Madrid was calculated using a pre-defined socioeconomic index, which considers 4 domains based on 7 socioeconomic indicators ([Martín-Turrero et al., 2022](#); [Gullón et al., 2017](#); [Borrell et al., 2017](#); [Díez et al., 2019](#)): (1) education (based on percentage of people above 25 years with low education, percentage of people above 25 years with high education), (2) employment (based on percentage of workers with part-time jobs, percentage of workers with temporal jobs, percentage of workers with non-qualified or manual employments), (3) wealth (based on average housing prices), and (4) living conditions (based on unemployment rates). All variables within each domain were weighted equally, where a Z-score of each indicator was averaged to obtain a Z-score for the domain. Finally, the 4 domains were averaged and each of them had a weight of 0.25 in the final composite SEP index. Census tracts were then categorized into tertiles of area SEP.

2.4. Causal structure: a Directed Acyclic Graph approach

We constructed a Directed Acyclic Graph (DAG) to formalize the underlying causal assumptions and guide the selection of confounding variables in our analyses ([Textor et al., 2017](#)). To operationalize this process, the research team convened to review previous evidence and jointly agreed on the causal links between variables. We then consulted a sample of experts familiar with alcohol research and the local context (epidemiologists, sociologists, statisticians, and health geographers) to further refine and validate the DAG ([Martín-Turrero et al., 2024](#)). [Table 1](#) summarizes the variables included in the DAG and the rationale for their connections. Each row presents in the first column, a variable considered relevant to the causal structure of the DAG. The second column outlines the specific relationships each variable holds with others in the graph, reflecting hypothesized causal links. The third column provides supporting evidence from the literature, which was used to justify the inclusion of each connection.

From the DAG, we derived the minimal sufficient adjustment set to estimate the direct effect of alcohol outlet density on adolescent alcohol consumption, while avoiding bias due to confounding or collider stratification. The final DAG and adjustment set are presented in [Fig. 1](#).

2.5. Statistical analyses

We combined the responses from the students' surveys with the physical availability of alcohol outlets gathered in the fieldwork in form of alcohol outlet densities around each school. Each student was imputed with the value of alcohol outlet density of the school they attended to using school ID codes.

Statistical analyses were completed in two steps. First, we used a descriptive table to assess how sociodemographic characteristics and area-level factors were related to having drunk ever in life. Secondly, we performed Multilevel Poisson regression models with robust variance ([Gullón et al., 2017](#)) to examine if adolescent drinking outcomes (i.e.,

Table 1

Variables considered to build the Directed Acyclic Graph that represents the assumed causal relationships between physical alcohol availability around schools and alcohol consumption in adolescents.

Variable	Directly affects/Rationale	Evidence
Physical alcohol availability around schools (exposure)	Adolescent drinking, perception of easiness to access alcohol, alcohol advertising and promotion, and level of consumption of parents	(Pastor et al., 2020b; Gmel et al., 2016; Tobler et al., 2011; Popova et al., 2009; Paschall et al., 2014; de et al., 2020)
Adolescent drinking (outcome)	-	
Area socioeconomic position (SEP)	Areas with lower SEP have been proven to have higher alcohol outlet density and more advertising and promotion of alcohol.	(Pastor et al., 2020b; Martín-Turrero et al., 2022)
Alcohol advertising and promotion	Affects the perception of easiness to obtain alcohol and the risk perception of its consumption.	(Bosque- et al., 2014; Kuo et al., 2003)
Perception of easiness to obtain alcohol	Affects adolescent consumption, through perception of opportunity to access alcohol.	(Rowland et al., 2014, 2016)
Risk perception of alcohol consumption	Affects adolescent consumption, through perception of absence of risks or consequences when consuming alcohol.	(Martínez-Manrique et al., 2022; Yanez et al., 2020)
Population density	Areas with higher population density are characterized by more heterogenic land use, including more recreational uses (as compared to areas with lower population density characterized by a primarily residential land use). This affects the number of alcohol outlets found in different areas.	(Martín-Turrero et al., 2023; Myran et al., 2019)
Age	Influences alcohol consumption patterns through cultural norms, risk perception and peer pressure. It can also influence the perception of easiness, parental monitoring and pocket money, where older adolescents might find it easier to access alcohol, have less monitoring and receive more pocket money.	(Martínez-Manrique et al., 2022; Rowland et al., 2014; Mills et al., 2021; Punitha, 2014; Shin, 2023; Vargas- et al., 2020)
Gender	Influences alcohol consumption patterns through cultural norms, risk perception and peer pressure. It can also influence parental monitoring.	(Martínez-Manrique et al., 2022; Mills et al., 2021; Jovićić et al., 2021)
Peer pressure	Adolescents drink to conform to social norms, avoid rejection, or gain social acceptance.	(Ivaniushina and Titkova, 2021; Teunissen et al., 2012)
Educational level of parents	Parents with higher education may drink less or differently than those with lower education, influencing adolescent drinking through modeling behaviors or	(Wahlström et al., 2023; Jovićić et al., 2021; Pape et al., 2017)

Table 1 (continued)

Variable	Directly affects/Rationale	Evidence
	household norms; might have greater awareness of alcohol-related risks, shaping their attitudes and discussions with their children; have stricter supervision and rule-setting regarding alcohol use; and might have greater financial resources, which could affect the amount of money adolescents have available to spend on alcohol. Moreover, families with different education levels may live in neighborhoods with different SEP.	
Parental monitoring	Parents supervising their adolescents' use of alcohol and the consent to drink affect adolescent drinking.	(Gilligan et al., 2012; Hearst et al., 2007)
Pocket money	The amount of money that adolescents have available to spend weekly influences their perception of easiness to access alcohol and facilitates alcohol consumption.	(Vargas- et al., 2020; Lozza et al., 2023)
Level of consumption of parents	Influences normalization of alcohol consumption, decreasing the risk perception and influencing adolescent drinking.	(Wahlström et al., 2023; Inoura et al., 2020)
Nationality	Different national backgrounds may be associated with varying levels of access to education due to structural and historical factors, religious traditions, or different societal acceptance of drinking, leading to different levels of alcohol consumption.	(Sordo et al., 2015; Sirin et al., 2022)
Religion	Some religions discourage alcohol consumption, which affect the levels of alcohol consumption.	(Sordo et al. (2015))

ever drunk, having drunk in the past 30 days and in the past 7 days, and binge drinking in the past 30 days) varied with physical availability of alcohol and perceived easiness to obtain alcohol near school (Espelt et al., 2017). All analyses were adjusted by the minimal sufficient adjustment set identified in the DAG (i.e., by SEP area, educational level of parents and nationality); and had a random intercept at the school level. All adolescent drinking outcomes were analyzed using a series of nested Poisson regression models with robust variance, in which each model progressively added individual and area-level variables. Model 0 was the null model that contained only the dependent variable and the random effect. Model 1 included the individual-level variables and the random effect. Model 2, the full model, included the area-level variables, the individual-level variables, and the random effect.

Sensitivity analyses were done using density of just off-premises outlets and density of just convenience stores, as well as using 200 m buffers around schools for the count of alcohol outlets.

The analyses were developed using the *lme4* package (Bates et al.,



Table 2
Characteristics of the adolescents (n = 2295) stratified according to having drunk ever in life. Madrid, 2021-2022.

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3. Results

Table 2 outlines the sociodemographic characteristics of the students' sample regarding their alcohol consumption ever (outcome variable). 67.0% of the interviewed adolescents had consumed at least once in their life. This proportion was higher for female (73.9%) than male population (60.4%). There was little difference between the percentage of drinkers among Spanish and non-Spanish students, however we observed higher percentage of alcohol consumption among those students that attended optional high school education compared to their younger counterparts that attended mandatory high school education (80.4% and 60.8%, respectively). Students that had ever drunk received a mean of 5.67 euros more weekly than those who had not drunk. Almost 80% of the students that reported having drunk perceived that drinking alcohol had a few or no problems. We found higher prevalences of drinking among those students whose parents' levels of consumption were higher, and those that went to school in higher SEP areas.

Fig. 2 shows the percentage of adolescents who drunk ever in life by alcohol outlet density and perception of easiness to access alcohol around school. We observed that the percentage of adolescents that drank alcohol did not follow a trend regarding alcohol outlet density in 500m buffers around schools, and the percentage of adolescents that drank was above 58% for all strata. Regarding perception of easiness to access alcohol around school, we observed that the percentage of adolescents that have ever drunk is bigger in the group that perceived that it was easy to access alcohol.

The average number of alcohol outlets within 500m street network buffers around the 49 schools included in this study was 79.4. Only 3 of the 49 schools had 0 outlets around.

Table 3 and Table 4 present results of the Poisson regression models that evaluate the association between physical alcohol availability (i.e., alcohol outlet density), with alcohol drinking outcomes in adolescents (i.e., ever drunk, having drunk in the past 30 days and in the past 7 days, and binge drinking in the past 30 days). Our results did not show a significant association between alcohol outlet density around schools and prevalences of alcohol consumption in adolescents or binge drinking. In areas of middle and middle-high densities of alcohol outlets, the percentage of adolescents that drank alcohol in the past 30 days was lower compared to adolescents that studied in areas with low densities of alcohol outlets (37 % and 42%, respectively). Similar results were found for binge drinking in the past 30 days, where the numbers were 39% and 47% in middle-low and middle-high areas, respectively. Moreover, a higher percentage of adolescents going to school in areas of advantaged SEP had drunk in the past 7 days (63%), compared to those in most disadvantaged SEP areas. Finally, no relationship was found between alcohol consumption and nationality or the highest level of education of the parents.

Similar results were obtained for area SEP when conducting the

analyses just for density of off-premises alcohol outlets and density of convenience stores (see [Supplementary Material Table S1 and S2](#)), as well as for density of alcohol outlets around schools in 200m buffers (see [Supplementary Material Table S3](#)).

4. Discussion

In this study, we did not find a significant association between alcohol outlet density around schools and adolescent alcohol consumption in Madrid, Spain. Area SEP showed a strong relationship with alcohol use, with adolescents from higher SEP areas reporting higher consumption levels.

We observed that the variability in the number of alcohol outlets within 500m of schools did not have a clear association with the prevalence of alcohol consumption in adolescents. Statistically significant results were found only when analyzing drinking prevalence and binge drinking in the past 30 days, where adolescents that went to school in areas of middle outlet density drank less than those attending school in areas of low outlet density. However, these associations disappeared in our sensitivity analyses filtering off-premises and convenience stores only ([Textor et al., 2017](#)).

A potential explanation for these results, which conflict with some of the previous literature ([Martín-Turrero et al., 2024](#)), might be the alcohol outlet overprovision in Madrid. Schools had an average of 79 alcohol outlets within 500m, and only 3 of the schools included in this study reported 0 alcohol outlets around (6% of our sample). This number of outlets is much higher than that found in similar studies, such as one conducted in New Brunswick (Canada), which reported an average of between 3 and 16 alcohol outlets around schools within a walking distance of 499 m ([Slaunwhite et al., 2017](#)). The situation of alcohol overprovision leads to thinking that those adolescents who wish to consume alcohol will find their way to do so ([Sureda et al., 2018](#)).

This interpretation aligns with the other studies in the literature that suggest a non-linear or threshold-effect in the association between alcohol outlet density and alcohol consumption. These studies argue that once outlet density reaches a certain high level, increases in availability no longer translate into higher consumption. One study showed that in highly saturated urban neighborhoods in the United States, the association between outlet density and binge drinking flattened at higher density levels, suggesting diminishing marginal effects once availability surpasses a critical point ([Ahern et al., 2013](#)). Similarly, recent simulation work demonstrated that in dense urban areas, zoning interventions have smaller impacts on consumption when baseline outlet density is already very high, because young people can rapidly substitute one outlet for another ([Ji et al., 2025](#)).

We observe that alcohol consumption is widespread throughout our adolescent population, where 67% of adolescents (73.9% of females, 60.4% of males and 70.0% of other) between the ages of 14-18 had

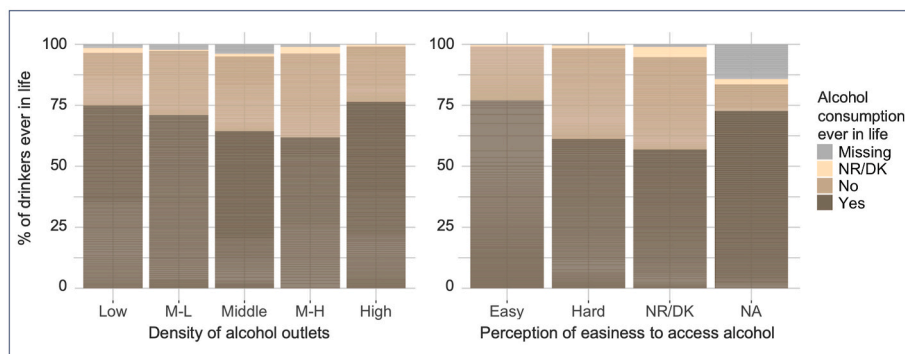


Fig. 2. Percentage of adolescents (14-18 years old) that have drunk alcohol ever in life, according to the density of alcohol outlets in 500m buffers around their schools (left panel), and according to their individual perception of easiness to access alcohol around school (right panel). M-L: Middle-Low; M-H: Middle-High; NR/DK: No Response/Does Not Know; NA: Not Applicable.

Table 3

Association between alcohol outlet availability (quintiles) in 500m buffers around schools and prevalence of alcohol consumption ever in life and in the past 30 days among adolescents in Madrid, 2021–2022.

	Alcohol consumption ever in life			Alcohol consumption in the past 30 days		
	Model 0	Model 1	Model 2	Model 0	Model 1	Model 2
	(null)	(Model 0+ individual variables)	(Model 1 + area-level variables)	(null)	(Model 0+ individual variables)	(Model 1 + area-level variables)
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
INDIVIDUAL VARIABLES						
Nationality						
Spanish		1	1		1	1
Non-Spanish		1.04 (0.73, 1.17)	1.06 (0.93, 1.21)		0.88 (0.71, 1.07)	0.89 (0.73, 1.10)
Highest level of education of parents						
No University		1	1		1	1
University		0.98 (0.88, 1.10)	0.96 (0.85, 1.07)		1.01 (0.87, 1.18)	0.99 (0.84, 1.15)
AREA-LEVEL VARIABLES						
Density of alcohol outlets (quintiles)						
Low (Q1)			1			1
Middle – Low (Q2)			0.94 (0.79, 1.10)			0.83 (0.60, 1.15)
Middle (Q3)			0.84 (0.69, 1.03)			0.63 (0.43, 0.93) *
Middle – High (Q4)			0.87 (0.71, 1.06)			0.58 (0.38, 0.88) *
High (Q5)			0.92 (0.78, 1.09)			0.88 (0.64, 1.23)
School area SEP (tertiles)						
Low (T1)			1			1
Middle (T2)			1.06 (0.91, 1.24)			1.24 (0.92, 1.69)
High (T3)			1.15 (0.97, 1.37)			1.28 (0.92, 1.80)
Intercept	0.69 (0.65–0.73) *	0.70 (0.64, 0.77) *	0.72 (0.61, 0.86) *	0.41 (0.37, 0.47) *	0.44 (0.37, 0.51) *	0.47 (0.34, 0.66) *

(*) $p < 0.05$. PR: Prevalence Ratio. CI: Confidence Interval.

Table 4

Association between alcohol outlet availability (quintiles) and prevalence of alcohol consumption in the past 7 days and binge drinking in the past 30 days among adolescents in Madrid, 2021–2022.

	Alcohol consumption in the past 7 days			Binge drinking in the past 30 days		
	Model 0	Model 1	Model 2	Model 0	Model 1	Model 2
	(null)	(Model 0+ individual variables)	(Model 1 + area-level variables)	(null)	(Model 0+ individual variables)	(Model 1 + area-level variables)
	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)	PR (95% CI)
INDIVIDUAL VARIABLES						
Nationality						
Spanish		1	1		1	1
Non-Spanish		0.92 (0.73, 1.17)	0.94 (0.74, 1.19)		0.97 (0.76, 1.24)	0.98 (0.77, 1.26)
Highest level of education of parents						
No University		1	1		1	1
University		0.98 (0.82, 1.18)	0.96 (0.80, 1.16)		1.03 (0.85, 1.25)	1.02 (0.83, 1.24)
AREA-LEVEL VARIABLES						
Density of alcohol outlets (quintiles)						
Low (Q1)			1			1
Middle – Low (Q2)			0.72 (0.45, 1.16)			0.61 (0.37, 0.98) *
Middle (Q3)			0.66 (0.39, 1.14)			0.64 (0.37, 1.11)
Middle – High (Q4)			0.57 (0.31, 1.01)			0.53 (0.30, 0.96) *
High (Q5)			0.85 (0.53, 1.36)			0.84 (0.52, 1.35)
School area SEP (tertiles)						
Low (T1)			1			1
Middle (T2)			1.31 (0.85, 2.02)			1.27 (0.82, 1.95)
High (T3)			1.63 (1.01, 2.62) *			1.28 (0.79, 2.07)
Intercept	0.22 (0.19–0.26) *	0.24 (0.19, 0.29) *	0.24 (0.15, 0.38) *	0.21 (0.18, 0.26) *	0.22 (0.18, 0.27) *	0.26 (0.16, 0.41) *

(*) $p < 0.05$. PR: Prevalence Ratio. CI: Confidence Interval.

drunk at least once in their life. This pattern is opposite to what has been observed in previous research, where males had higher prevalences of drinking than females (Martínez-Manrique et al., 2022; Jovićić et al.,

2021). However, the findings align with recent international evidence showing a narrowing gender gap in adolescent drinking, with females in several countries now equaling or surpassing males in alcohol use. This

shift has been linked to changing gender norms, evolving peer dynamics, and the symbolic use of alcohol as part of female identity and empowerment processes (Martínez-Manrique et al., 2022; Jovićić et al., 2021).

Moreover, adolescents that perceived that obtaining alcohol near their school was easy (vs. hard), reported having drunk more. The vast number of outlets present throughout the city together with the associated alcohol promotions and signs of consumption that are present in establishments (Pastor et al., 2020a, 2020b), might affect the perception of adolescents on the acceptability, normalization and easiness to obtain alcohol, even when the establishments are closed or when adolescents cannot obtain alcohol directly because of their age (Sureda et al., 2017, 2018; Pastor et al., 2022). In a qualitative study performed previously in the city of Madrid (Molina-de la Fuente et al., 2021), participants from both disadvantaged and advantaged SEP districts referred to the large number of establishments selling alcohol, their diversity, long opening hours, and range of prices. They agreed that the high exposure to alcohol outlets and advertising (sometimes even targeted at young populations) in their neighborhoods influenced alcohol acceptance in this population.

Higher prevalences of drinking were found in adolescents that attended school in areas of high SEP. These adolescents may have more pocket money to spend, which can lead to increased consumption. Indeed, in this study we see that those individuals that had greater amounts of pocket money weekly (5.7 euros more on average than their counterparts) had higher prevalence of alcohol consumed in life. It is well studied that alcohol consumption in advantaged SEP areas is often higher than in low SEP areas, however, the latter suffer from higher rates of alcohol-related harm compared with advantaged groups. This is known as the alcohol harm paradox (Legleye et al., 2024; Bellis et al., 2016).

On the other hand, this association between SEP and consumption can also be explained from a geographical point of view, analyzing the differences in the land use distribution, including the distribution of alcohol outlets throughout the city of Madrid (Kerr et al., 2012). High SEP areas in Madrid are usually either residential areas in the outskirts of the city with low access to alcohol outlets, or central areas of the city (i. e., downtown) (Martín-Turrero et al., 2022). These central areas tend to have higher densities of alcohol outlets, since they are characterized for their offer of leisure and nightlife activities, together with establishments that attract tourists (Villalbí et al., 2019; Martín-Turrero et al., 2022). These types of outlets are usually not targeting adolescents as their main audience; however, they contribute to the exposure and normalization of alcohol use.

Understanding the environmental factors to which adolescents are exposed is indispensable to understand acceptability of alcohol within populations and alcohol consumption. In this study, we only measured the availability of alcohol around the schools, which does not necessarily reflect the broader activity space of individuals. This is especially important in cities, where students often travel significant distances to attend school, meaning that their school environment may not coincide with their residential surroundings (Nelson et al., 2008; Martín-Moraleda et al., 2023). This is especially true for minors that attend private schools. Thus, in future studies it might be interesting to explore other area-level factors unrelated to school surroundings and understand in which spaces adolescents spend most of their spare time. Moreover, context alone may not be sufficient to predict drinking behaviors. Alcohol consumption in adolescents is also associated with a wide variety of individual factors.

In our study, we observe differences in the prevalences of adolescents that drink regarding gender, age, perceived risk of drinking alcohol and levels of alcohol consumption of the parents. Those adolescents that are females, older, have lower perception of risk, and parents that abuse alcohol, reported higher prevalences of drinking. Different studies have proved that the familiar and social environment of adolescents influence the normalization of alcohol, and its latter consumption (Teunissen et al., 2012; Yuen et al., 2020; Martínez-Montilla et al., 2020).

Alcohol consumption is framed under a big umbrella of influential

individual and environmental factors, from which, partially, the lack of state and country level health policies are responsible. For decades, Spain's legal framework addressing underage alcohol consumption has remained outdated, with national regulations often lagging the growing body of scientific evidence highlighting the detrimental effects of early alcohol use on adolescent development. To date, very few policies restricted alcohol availability and accessibility in Spain. In a significant policy shift, the Spanish government approved the "Draft Law on the Prevention of Alcohol Consumption and Its Effects on Minors" in March 2025. This project introduces some measures in the urban planning field, including restrictions on alcohol advertising near schools, and considering the current provision of alcohol outlets around schools before issuing licenses for new establishments.

Although the proposals and actions are not very precise, as they do not present specific numbers regarding the maximum density or proximity to alcohol outlets around schools, and the legislation is limited to new establishments (i.e., not affecting those outlets that are already in school areas with an oversupply), the approval of this project is extremely important as it reopens the debate on alcohol at the state level, a topic that had not been reviewed in over two decades. The enactment of this law marks a critical turning point in Spain's public health approach, reigniting national discourse on alcohol-related harms and underscoring the urgency of implementing evidence-based interventions. Our study contributes to this evolving landscape by providing empirical data that supports the law's implementation and highlights the necessity for ongoing evaluation and the introduction of additional restrictions to effectively safeguard youth health.

It is also important to note that, although there are few laws that regulate access to alcohol in adolescents (such the legal age of drinking), these appear to be poorly enforced. If enforcement was effective, adolescents would likely not perceive alcohol as so easy to acquire and consume. Similar results have been reported also in other countries (Yoon et al., 2017; Erickson et al., 2013). Therefore, the approval and implementation of new legislation must be accompanied by effective enforcement strategies to ensure their impact.

This study has some strengths. It is one of the first studies in Europe that accounts for the relationship between alcohol drinking in adolescents and physical outlet density, creating a DAG to explore the possible effect of other contextual and individual variables in this association. This methodological choice strengthens the theoretical foundation of the analyses and enhances the transparency and reproducibility of variable selection. Additionally, the study was performed in a wide sample of 2295 adolescents, distributed through 49 schools, which accounted for different SEP and alcohol outlet density areas within the city of Madrid. Moreover, although alcohol exposure and consumption in adolescents have been studied previously in the literature (Martín-Turrero et al., 2024), Madrid is an interesting and unique setting to study due to its alcohol overprovision and cultural acceptance of alcohol consumption. Another strength is that alcohol outlet density was obtained through Systematic Social Observation (SSO), which offers a powerful methodological approach for understanding the complex interplay between social and environmental factors that shape health-related behaviors and outcomes. SSO allows researchers to capture temporal dynamics and changes in environmental conditions over time. In fact, in this study the environmental conditions around the schools were collected at the same time that the questionnaires were given to adolescents that attend those schools.

This study also has some limitations. While self-reported data can provide valuable insights in public health research, researchers must be aware of its limitations. It relies on individuals' memory and honesty, which can vary widely and may lead to inaccuracies or biases. Participants may forget details or may be inclined to provide socially desirable responses (Khalili et al., 2021). Another limitation of this study may be the way alcohol consumption has been measured. In a country like Spain, where alcohol is culturally normalized and highly accessible, measuring prevalence of alcohol use among adolescents may be

insufficiently sensitive to capture the full scope of the public health issue. The prevalence of alcohol consumption is so widespread that simply identifying whether an adolescent has consumed alcohol or not does not necessarily reflect problematic or risky patterns of use. This could lead to an underestimation of the association between exposure (i. e., alcohol outlet density) and harmful outcomes. Including a variable that distinguished between low-risk and high-risk drinking (such as consumption exceeding health-based thresholds) in future studies could allow a more nuanced analysis. An additional limitation is that data collection took place shortly after the COVID-19 pandemic, a period during which adolescent alcohol use patterns were known to fluctuate in response to restrictions. Therefore, some of the observed prevalence estimates may partially reflect these post-pandemic behavioral shifts (Rogés et al., 2024; Ross et al., 2024).

Moreover, in addition to physical availability of alcohol outlets around schools and SEP, this study does not account for other ways in which the environment can affect perception of easiness to obtain alcohol and consumption, such as physical availability and promotion around residence, obtention of alcohol through peers, promotion through social media, affordability or sales online (Morrison et al., 2019a, 2019b; Colbert et al., 2021). It is evident that many factors can influence adolescents' perception of easiness to access alcohol (which in turn translate into more drinking), but further research is needed to narrow down the most influential ones to be able to tackle them properly. For example, evaluating how promotion of alcohol can affect the perception of alcohol, or doing qualitative work to delve into the reasons that make adolescents normalize and drink alcohol.

5. Conclusions

In this study alcohol consumption was widespread among adolescents in Madrid. Levels of consumption were not associated with the density of alcohol outlets around schools. The general overprovision of alcohol outlets throughout Madrid likely creates a saturated environment in which marginal differences in local density have limited influence on consumption. However, area SEP played an important role in adolescent drinking, reflecting differences depending on financial resources. Alcohol consumption is a complex dynamic, that emerges from cultural norms, environmental and individual factors. Currently, the lack of compliance and need to strengthen the existing alcohol policies leaves a great room for improvement. Future research should inform preventive strategies that tackle the complex dynamics of alcohol drinking at these early stages in life.

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CRediT authorship contribution statement

Irene Martin-Turrero: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing – original draft, Writing – review & editing. **David Prieto-Merino:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Roberto Valiente:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Supervision, Writing – review & editing. **Albert Espelt:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – review & editing. **Xisca Sureda:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision,

Writing – review & editing.

Declaration of interest

Xisca Sureda currently holds the position of Government Delegate for the Spanish National Plan on Drugs. Her current role had no influence on the funding decision, study design, data collection, analysis, interpretation of results, or the decision to publish this work. The research was conducted with full scientific independence, and the author declares no conflicts of interest related to her institutional position.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.healthplace.2026.103669>.

Data availability

Data will be made available on request.

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